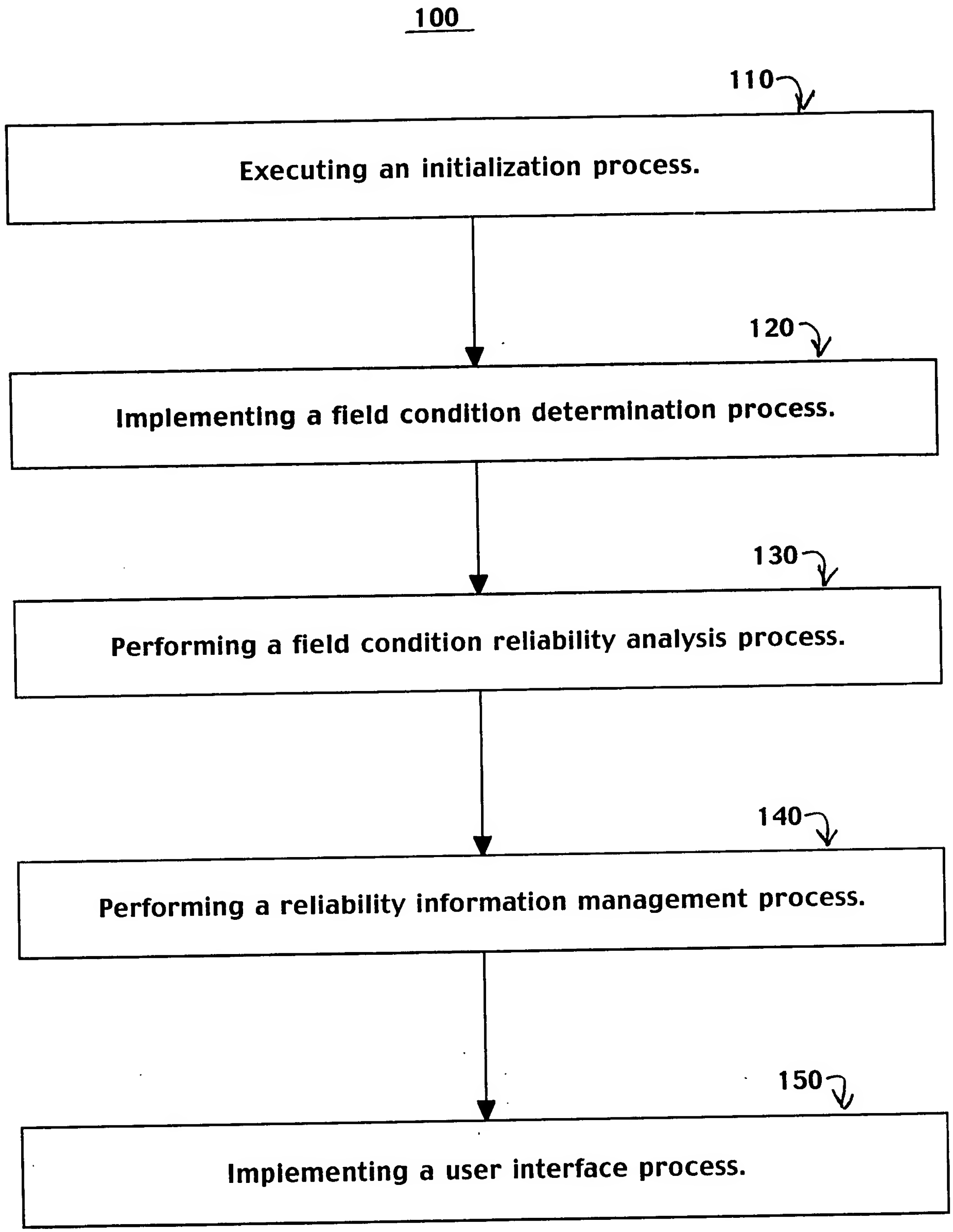
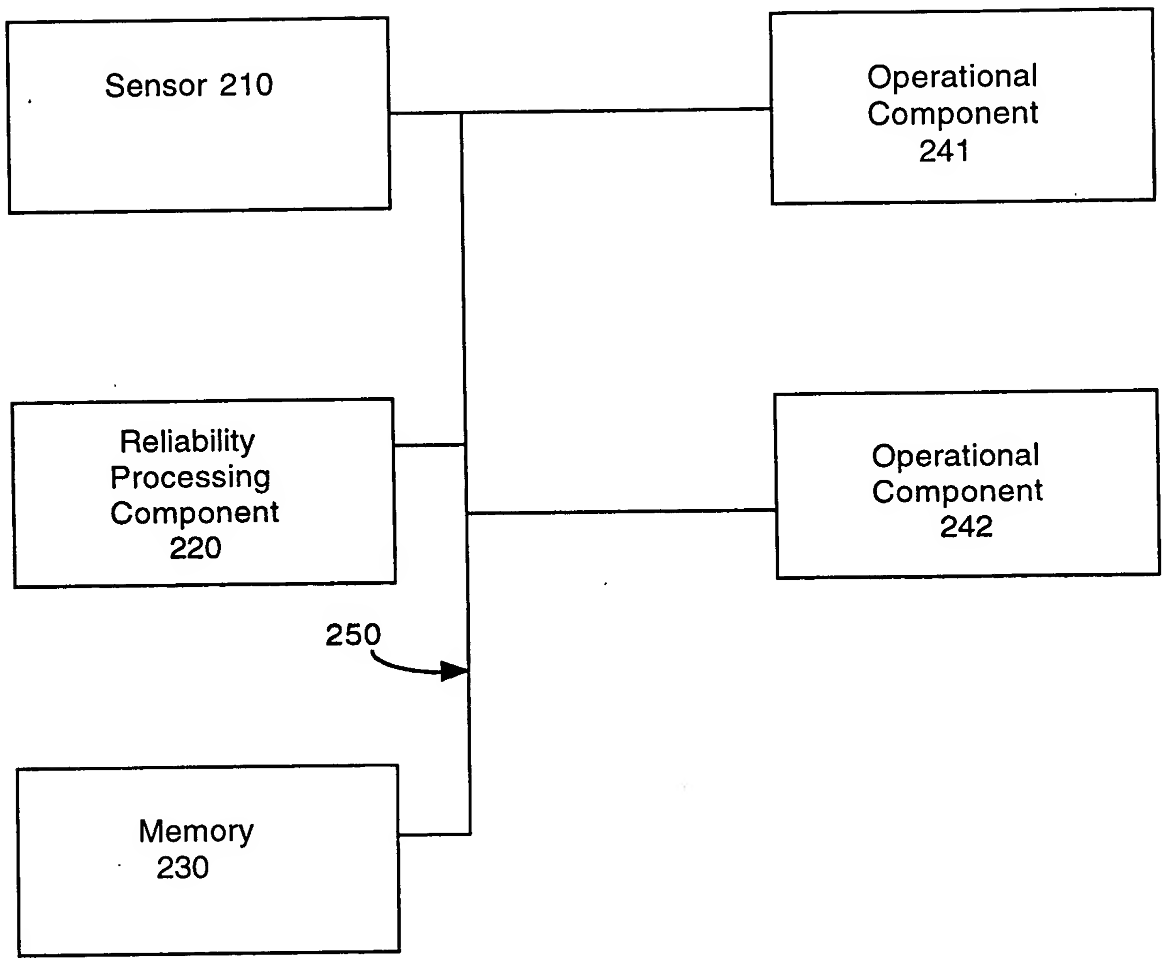

100
110
Executing an initialization process.
120
Implementing a field condition determination process.
130
Performing a field condition reliability analysis process.
140
Performing a reliability information management process.
150
Implementing a user interface process.

FIG 1

200



Sensor 210
Operational Component 241
Reliability Processing Component 220
Operational Component 242
250
Memory 230

FIG 2

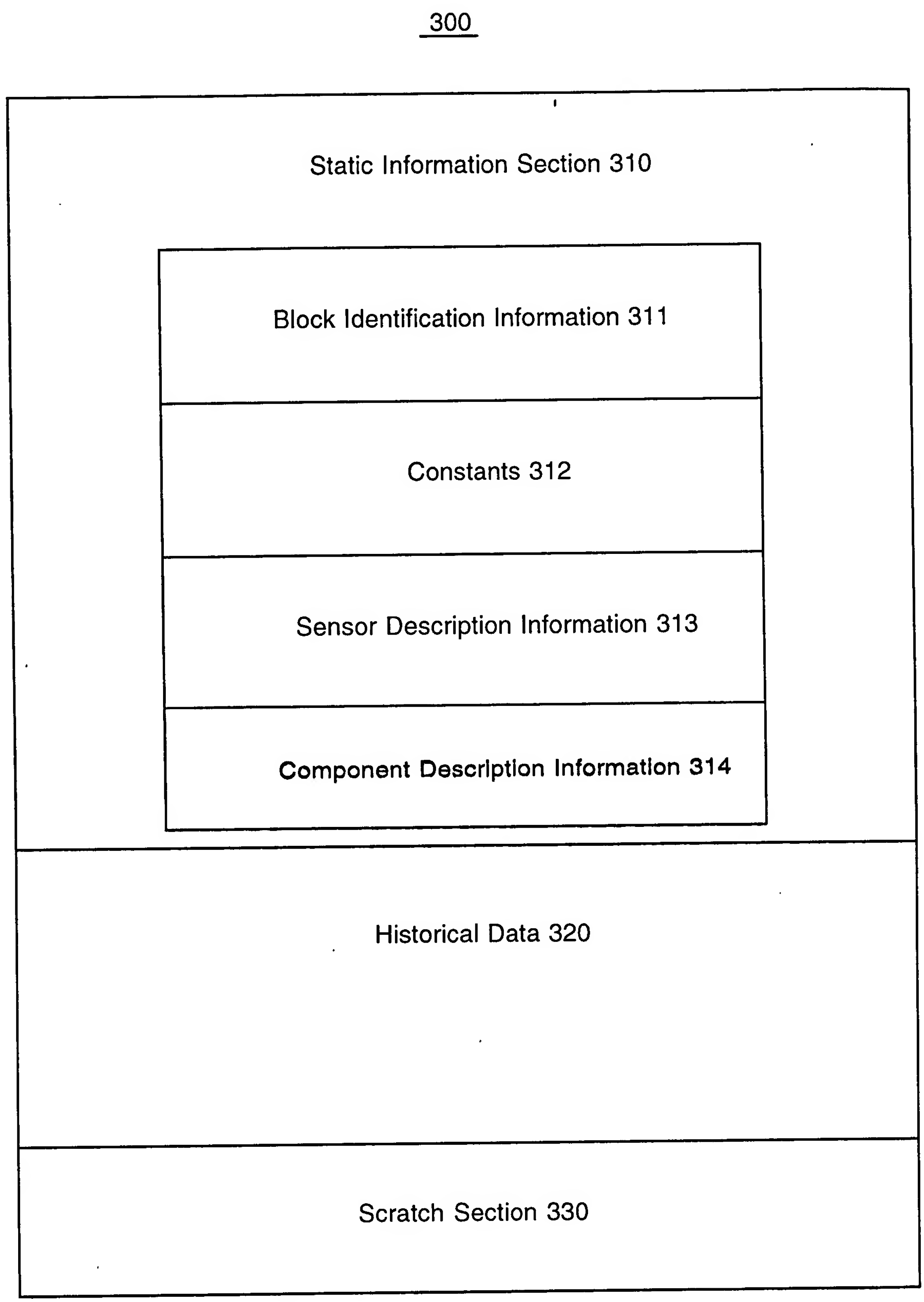

300
Static Information Section 310
Block Identification Information 311
Constants 312
Sensor Description Information 313
Component Description Information 314
Historical Data 320
Scratch Section 330

FIG 3

400

Historical temperature data - Flash structure Block 0 - Static data		
Block identification This is the signature to validate the block 0 data. Checking this format FW will know data are present. The version number is necessary for every future variation of the structure. The base address is : 1FC0 0000 + 2Mbytes = 1FE0 0000		
string_id	24	$$**__xRELIABILITY__**$$
version	1	Structure version number - 1
format_time	4	Time of Format – minutes since 1/1/70 00:00:00
blk_chksum	2	Block checksum
reserved	33	Reserved for future use
Time constants These are the constant values for sampling and saving data. If the save time is greater than 1 what is saved is the average temperature read in the interval. The offset of this block is fixed at 64 bytes from the base address of the flash block.		
blk_id	2	=0x4254 "BT"
blk_chksum	2	Block checksum
bkg_t	1	Time for sampling backgroud task - δ - in minutes
averagesample_t	1	Max time for temperature sample – $\Delta tmaxav$ - multiples of δ
flashsave_t	1	Max time to save data to Flash - $\Delta tmaxf$ - multiples of δ
flashclearsave_t	2	Max number of consecutive compress. rec. - $\Delta nmaxcl$
reserved	55	Reserved for future use
Sensors description The sensors are listed based on the position on the list. Each one has an ID number, the 2wire channel and the 2wire address to univocally identify it. The sensor ID This parameter IS the same reported in the TEMP component for the board. Every sensor will be numbered from 1 to N based on component's structure. Because we have different type of sensor it is possible that the read temperature IS adjusted. For example Reading the temperature for a sensor inside an ASIC GIVES the junction temperature so it IS adjusted to get the case temperature. if $sadjt_j == 0$ $T_{corr} =$ Tread + $sadv_j$ if $sadjt_j == 1$ $T_{corr} =$ Tread * (1 + $sadv_j$ /100) The offset of this block is fixed at 128 bytes from the base address of the flash block.		
blk_id	2	=0x4253 "BS"
blk_chksum	2	Block checksum
sensor_num	1	Number of sensors for the board - s
sensor_j	4	Sensor ID - sd_j
sensor_2w_chn	1	Sensor 2wire channel
sensor_2w_addr	1	Sensor 2wire address

FIG 4A

400 (CONTINUED)

sensor_adjust_type	1	*s	Sensor reading adjustment type - $sadjt_j$ - 0 = absolute - 1 = percent
sensor_adjust	1		Sensor reading adjustment value - $sadj_j$
sensor_DT_average	1		Delta Temp to be consid red average $\Delta Tavth$
sensor_DT_max	1		Max Delta Temp to be recorded with comp. $\Delta Tmaxth$

Component descriptor

One component is an HW module that can be correlated to a reliability function. Usually components are ASICs having an internal temperature sensor, but it is not limited to that. For this reason the form used to calculate the local temperature for the component is assumed of the form:

$$T_c = C + \Sigma_s \, cw_s \, T_s$$

Where T_s is the temperature sampled in the generic sensor. The constant C and the weights cw_s can be determined by pre-FCS measurements and multivariate analysis. The acceleration factor is then:

$$A_c(T) = \exp((1/k) \, \Sigma_{nf} \, Eaf \, (1/(273+T_{ref}) - 1/(273+T_c)))$$

component_num	1		Number of the tracked Components - c
comp_id	4	*c	Component ID (32bit integer)
comp_type	1		Comp Type : PortAsic, Bridge, Fabric, ...
comp_inst	1		Comp sequential number
fr_ref	8		Reference failure rate Λ_c (1/hr , double)
spec_comp_numb	1		Number of this specific component
comp_archit	1		Component architecture csa 0 = serial 1 = redundant
actv_en_num	1		Number of activation energy - nf
actv_en	8* nf		Electronic failure activation energy - Eaf(c,f) - eV (double)
temp_accel_ref	1		Reference temperature for accel. Factors T_{ref} (°C)
temp_w_const_coeff	8		Constant term for temperature definition C (double)
temp_w_exp_coeff	s*8		Weigth for expansion temperature determination cw_s(double)

Block 1-30 - Historical data

This part contains historical temperature data. For the format please see par. 4.

Block 31 – Scratch sector

This sector is used as scratch during erase/write of a complete data sector

FIG 4B

500

RAM Memory			
bit-sz	Symbol	Mem-sz	Description
16	δ	1	Reading interval in minutes (15 min)
16	tsave	1	Saving values to NV time (tsave*δ)
32	t1	1	Limit time for infant mortality (t1*δ)
32	t2	1	Limit time for wear out (t2*δ)
64	ba	1	Min value for β (at t=0)
64	bb	1	Max value for β (reached at t=2*t2)
8	nf	1	Number of possible electronic failures
64	Eaf[]	nf	Activation energy per failure /8.63 10^{-5} (eV/k)
8	Nj	1	Component number
32	CompIDj	Nj	Identifier
64	Λj		Reference failure rate
64	Trefj		Reference temperature (°K)
8	Cnumj		Number of this specific components
8	Ttype		Temperature measurement (CaseT, indirect)
8	Carch		Architecture (serial, redundant)
64	mj		% of traffic factor
8	Prefj		% of traffic reference factor (50)
64	PosFct		Position factor
64	Λs	1	System failure rate
32	t	1	Total ticks

64	B	1	Value for instantaneous β
			B=1
			If (t<t1) B=ba+((1-ba)/t1)*t
			If (t>t2) B=1+((bb-1)/t2)*(t-t2)

64	Rrefj[]	Nj	Reference reliability index per component $Rrefj[j]=exp[-(\Lambda j[j]*\delta*t)^{B}]$
64	Rrefs	1	System reference reliability index $Rrefs=exp[-(\Lambda s*\delta*t)^{B}]$
64	FRrefj[]	Nj	Failure rate index per component $FRrefj[j]= (\Lambda j[j])^{B}*B*(\delta*t)^{B-1}$
64	FRrefs	1	System failure rate index $FRrefs= (\Lambda s)^{B}*B*(\delta*t)^{B-1}$
64	Ajft[]	Nj*nf	Accelerator factor per component per failure Ajft[j,f]=exp[Eaf[f]*((1/ Trefj[j])-(1/(Tj[j]+273)))
64	Ajt[]	Nj	Accelerator factor per component $Ajt[j]=\Sigma_f (Ajft[j,f])$

FIG 5A

500 (CONTINUED)

bit-sz	Symbol	Mem-sz	Description
64	Ljt[]	Nj	Instantaneous failure rate per component Ljt[j]=Ajt[j]* Λj[j]
64	SRjt[]	Nj	Instantaneous contribution to the reliability index $SRjt[j]= (Ljt[j])^{B}*B*(\delta*t)^{B-1}$ $SRjt[j]= SRjt[j]*exp[-(Ljt[j]*\delta*t)^{B}]$
64	Rjt[]	Nj	Reliability index per component Rjt[j]=Rjt[j]-SRjt[j]
64	Lst	1	System instantaneous failure rate $Lst=\Sigma_j (Ljt[j])$
64	SRst	1	System inst. contribution to the reliability index $SRst= (Lst)^{B}*B*(\delta*t)^{B-1}$ $SRst= SRst*exp[-(Lst*\delta*t)^{B}]$
64	Rst	1	System reliability index Rst=Rst-SRst
16	BFsz	1	Ring buffer size
16	BFidx	1	Next avail. Row in ring buffer
32	tofT	BFsz	Reading time
8	Tin		Intake Temperature (°C)
8	Tex		Exhaust Temperature (°C)
8	Tj[Nj]		Case temperature per component (°C)
64	Lj[Nj]		Inst. failure index per component
64	Ls		System Inst. failure index
64	Rj[Nj]		Reliability index per component
64	Rs		System reliability index

FIG 5B

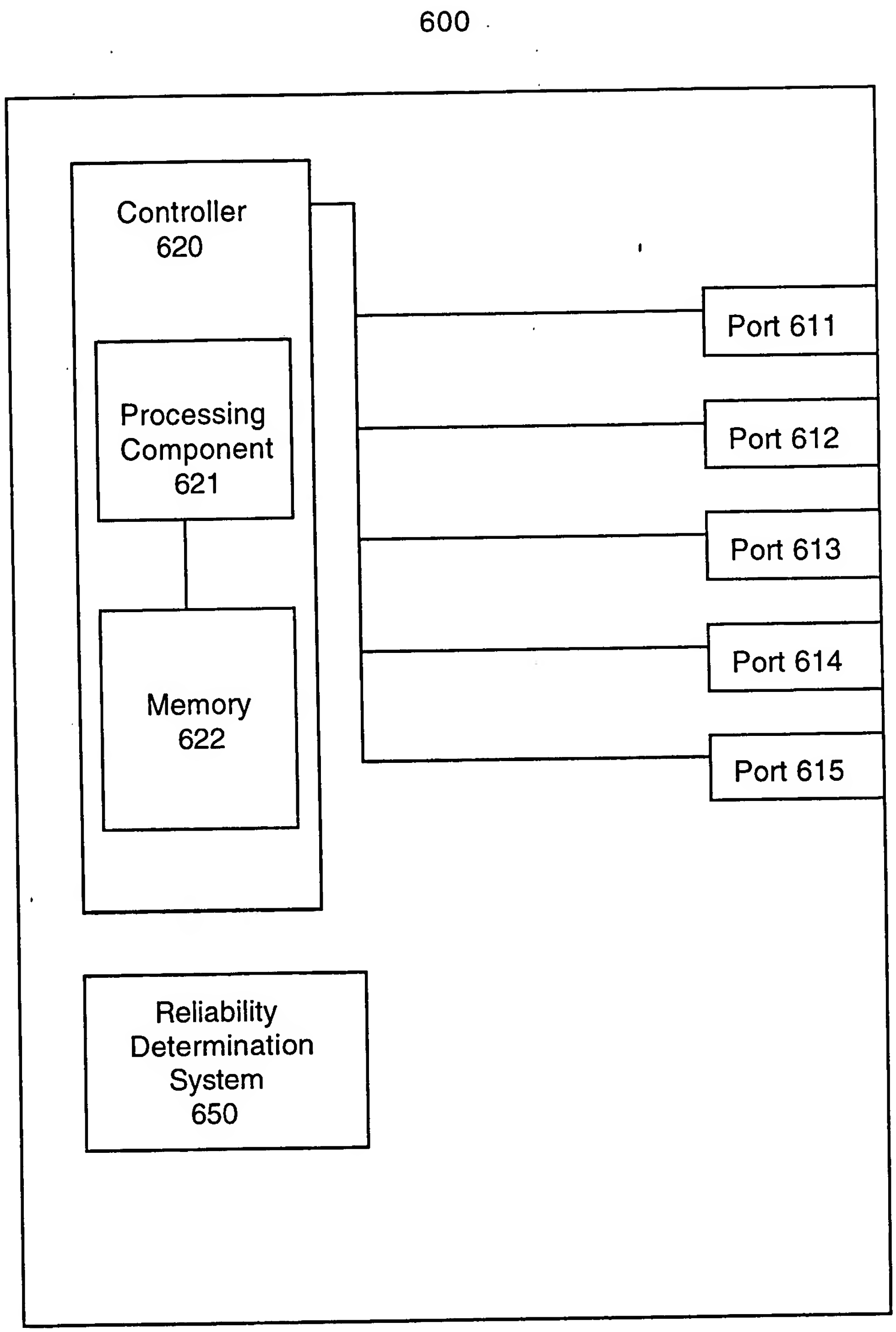

600
Controller
620
Processing
Component
621
Memory
622
Reliability
Determination
System
650
Port 611
Port 612
Port 613
Port 614
Port 615

FIG 6

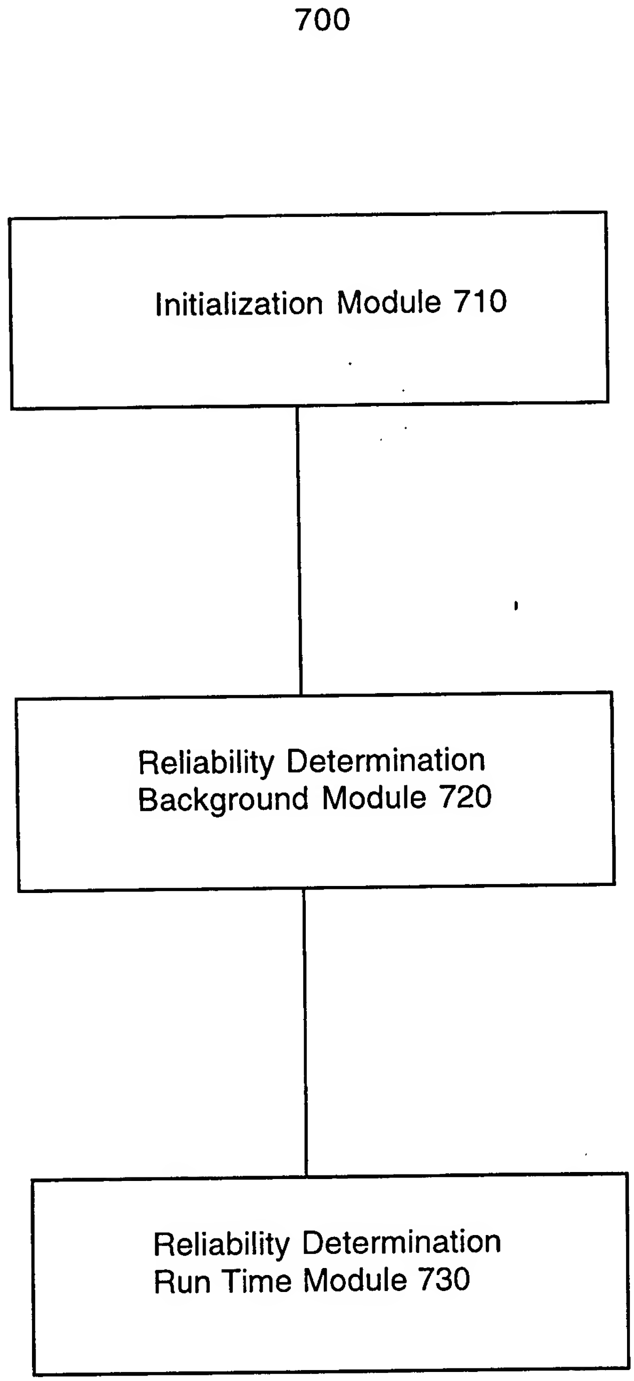

700
Initialization Module 710
Reliability Determination
Background Module 720
Reliability Determination
Run Time Module 730

FIG 7

800

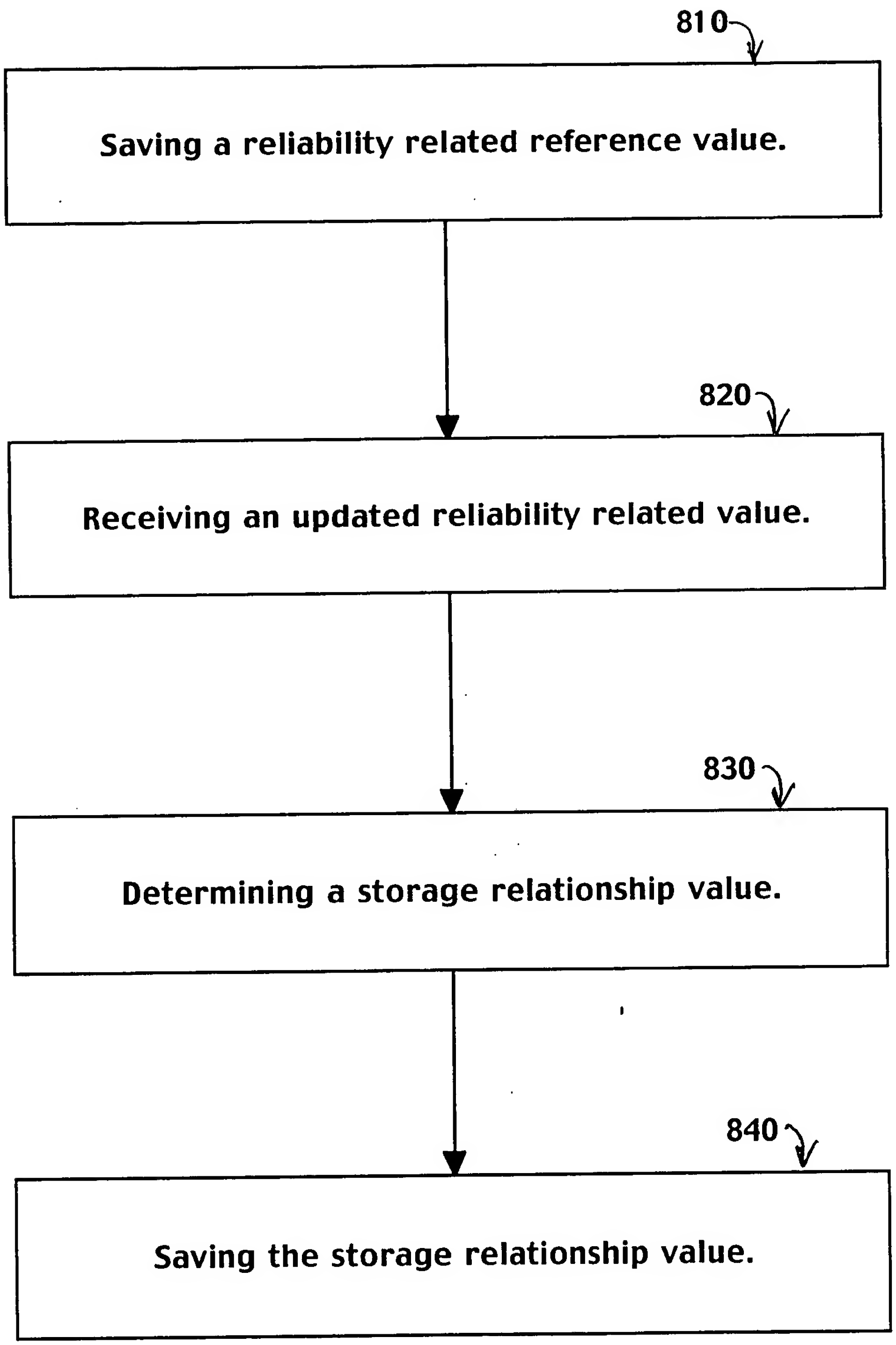

810
Saving a reliability related reference value.
820
Receiving an updated reliability related value.
830
Determining a storage relationship value.
840
Saving the storage relationship value.

FIG 8

910

Sensor 911	Sensor 912	Sensor 913	Time Interval 914
27	50	30	0C98719h
28	52	29	0C9871A3h
35	53	25	0C9871B2h

FIG 9A

910

Sensor 911	Sensor 912	Sensor 913	Time Interval 914
27	50	30	0C987194h
+1	+2	-1	1
+7	+1	-4	1

FIG 9B

910

Sensor 911	Sensor 912	Sensor 913	Time Interval 914
00011011b	00110010b	00011110b	0C87194h
0001b	0010b	1001b	01h
0111b	0001b	1100b	01h

FIG 9C